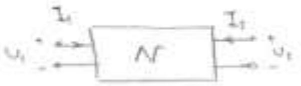
Sheet 1

(1) Z-parameter "open ct. parameter"

$V_1 = Z_{11} I_1 + Z_{12} I_2$

$V_2 = Z_{21} I_1 + Z_{22} I_2$



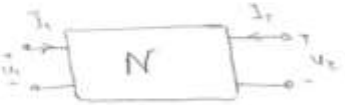
$$\begin{pmatrix} V_1 \\ V_2 \end{pmatrix} = \begin{pmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{pmatrix} \begin{pmatrix} I_1 \\ I_2 \end{pmatrix}$$

Z-Matrix

(2) Y-Parameter "short ct. parameter"

$I_1 = Y_{11} V_1 + Y_{12} V_2$

$I_2 = Y_{21} V_1 + Y_{22} V_2$



$$\begin{pmatrix} I_1 \\ I_2 \end{pmatrix} = \begin{pmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{pmatrix} \begin{pmatrix} V_1 \\ V_2 \end{pmatrix}$$

Y-Matrix

(3) Hybrid parameter

$V_1 = h_{11} I_1 + h_{12} V_2$

$I_2 = h_{21} I_1 + h_{22} V_2$

$$\begin{pmatrix} V_1 \\ I_2 \end{pmatrix} = \begin{pmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{pmatrix} \begin{pmatrix} I_1 \\ V_2 \end{pmatrix}$$

(4) Transmission parameter.

$V_1 = A V_2 - B I_2$

$I_1 = C V_2 - D I_2$

$$\begin{pmatrix} V_1 \\ I_1 \end{pmatrix} = \begin{pmatrix} A & B \\ C & D \end{pmatrix} \begin{pmatrix} V_2 \\ I_2 \end{pmatrix}$$

* if $Z_{12} = Z_{21}$ or $Y_{12} = Y_{21}$

$\therefore$ Reciprocal system

* if $Z_{11} = Z_{22}$ or $Y_{11} = Y_{22}$

$\therefore$ Symmetrical system

* Z-parameter $\longrightarrow$ T-Model

Y-parameter $\longrightarrow$ Π-Model

T-Model & Π-Model

. from (T → Π)

$$Z_A = \frac{Z_1 Z_2 + Z_1 Z_3 + Z_2 Z_3}{Z_2}$$

كل z جنب بعضيها
المقسوم عليه غير

$$Z_B = \frac{Z_1 Z_2 + Z_1 Z_3 + Z_2 Z_3}{Z_1}$$

$$Z_C = \frac{Z_1 Z_2 + Z_1 Z_3 + Z_2 Z_3}{Z_3}$$

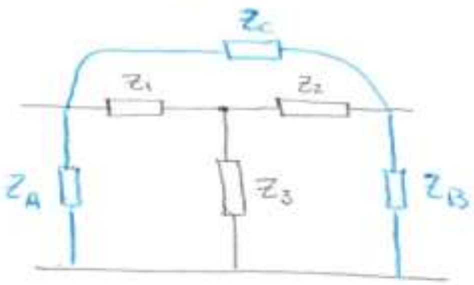
. from (Π → T)

$$Z_1 = \frac{Z_A Z_C}{Z_A + Z_B + Z_C}$$

الـ Z اللي قدامها [illegible]
[illegible] حاصل ضرب بعضها

$$Z_2 = \frac{Z_B Z_C}{Z_A + Z_B + Z_C}$$

$$Z_3 = \frac{Z_A Z_B}{Z_A + Z_B + Z_C}$$



→ Relationship among two port parameter.

$\boxed{1}$ $Z \rightarrow Y$

$$[Y] = [Z]^{-1} = \begin{bmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{bmatrix}^{-1} = \begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix}$$

$\boxed{2}$ $Y \rightarrow Z$

$[Z] = [Y]^{-1}$

$\boxed{3}$ $T \rightarrow Z$

$$Z_{11} = \frac{A}{C}$$

$$Z_{12} = \frac{AD}{C} - B$$

$$Z_{21} = \frac{1}{C}$$

$$Z_{22} = \frac{D}{C}$$

$\boxed{3}$ $Z \rightarrow T$

$$C = \frac{1}{Z_{21}}$$

$$D = \frac{Z_{22}}{Z_{21}}$$

$$A = \frac{Z_{11}}{Z_{21}}$$

$$B = \frac{Z_{11} Z_{22}}{Z_{21}} - Z_{12}$$

-2-

Sheet3

* check for Hurwitz.

. If $P(s) = s^3+2s^2+3s+6$ "Polynomial"

Sol:

even part $m(s) : 2s^2+6$

odd part $n(s) : s^3+3s$

أقسم الـ order الأكبر
على الـ order الأصغر
ولازم يطلع الـ 3 poles
علشان هو من 3rd degree

Ex: $s^7+2s^6+2s^5+s^4+4s^3+8s^2+8s+4$

Sol:- $m(s) = 2s^6+s^4+8s^2+4$

$n(s) = s^7+2s^5+4s^3+8s$

$$2s^6+s^4+8s^2+4 \,\big)\, s^7+2s^5+4s^3+8s$$

$$q_1 \leftarrow \boxed{\tfrac{1}{2}s} \qquad \overset{-}{s^7} \overset{-}{+} \tfrac{1}{2}s^5 \overset{-}{+} 4s^3 \overset{-}{+} 2s$$

$$\tfrac{3}{2}s^5+6s \,\big)\, 2s^6+s^4+8s^2+4$$

$$q_2 \leftarrow \boxed{\tfrac{4}{3}s} \qquad \overset{-}{2s^6} \overset{-}{+} 8s^2$$

$$s^4+4 \,\big)\, \tfrac{3}{2}s^5+6s$$

$$q_3 \leftarrow \boxed{\tfrac{3}{2}s} \qquad \tfrac{3}{2}s^5+6s$$

$$0$$

all are +ve

Ther is only 3 quotient only

∴ There is common factor

$$\begin{array}{r} s^3+2s^2+2s+1 \\ s^4+4 \,\big)\, s^7+2s^6+2s^5+s^4+4s^3+8s^2+8s+4 \\ \overset{-}{s^7} \qquad \overset{-}{+}4s^3 \\ \hline 2s^6+2s^5+s^4+8s^2+8s+4 \\ \overset{-}{2s^6}+ \qquad \overset{-}{+}8s^2 \\ \hline 2s^5+s^4+8s+4 \\ 2s^5+ \qquad 8s \\ \hline s^4+4 \\ s^4+4 \\ \hline 0 \end{array}$$

بقسم على آخر حاجة قسمت عليها فوقه
وبقسم قسمة مطولة عادي
طالعين زي بتاعة زمان.

$$(s^4+4)(s^3+2s^2+2s+1) = 0$$

$$s^4 = -4 \qquad \Downarrow$$

$$s^2 = \pm j2$$

هيطلع إيه غير الـ imj
برده

$$s = \pm\sqrt{2j} \qquad \pm\sqrt{2j}$$

Note:- لو قالك check Herwitz

$$P(s) = \frac{s^2+2s+1}{s^3+2s^2+2s+40}$$

Sol:-

$\therefore P(s) = N(s) + D(s) = s^3+3s^2+4s+41$

not Herwitz من غير اختبار

. if all quotients are +ve
∴ Hurwitz

. if one quotient is -ve
∴ not Hurwitz

∴ There is a multi poles at j axis
∴ not Herwitz.

إنما لو كان طلع بس مثلاً الـ $S = \pm j0$ و القوس
الثاني طلع كل الـ Poles بالـ -ve يعني LHS
يبقى Hurwitz

Test the following fun. wether they are PRF ~~or~~ OR not giving reasons:

given: $F(s) = \frac{N(s)}{D(s)}$

∴ condition to be PRF

$m_1 m_2 - n_1 n_2 \geq 0 \;\forall \omega$

- all poles lie in LHP
- All coeff are real & +ve

m_1 & m_2: even part in $N(s)$ & $D(s)$

n_1 & n_2: odd part in $N(s)$ & $D(s)$.

Note ملحوظة

قبل ما أعمل لازم أتأكد انه مفيش قوسين مضروبين فى بعض وزى بعض فوق او تحت يعنى مثلا لو لاقى

$F(s) = \frac{s(s+5)}{\underbrace{s^4+2s^2+1}}$

الجزء ده ممكن يبقى

$(s^2+1)(s^2+1)$ جذر متكرر

∴ not PRF because has a. multiples $(s^2+1)(s^2+1) = (s^2+1)^2$

ex: $F(s) = \frac{2s^3+3s^2+3s+3}{s^2+1}$

Sol: لازم أعمل check فى الأول على Hurwitz

$m_1 = 3s^2+3 \qquad n_1 = 2s^3+3s$

$m_2 = s^2+1 \qquad n_2 = 0$

$m_1 m_2 - n_1 n_2 = (3s^2+3)(s^2+1) - 0$

$= 3s^4+6s^2+3 \Big|_{j\omega}$

$= 3(j\omega)^4 - 6(j\omega)^2 + 3$

بعوض فى ω مرة بـ zero ومرة بأى رقم

$= 3\omega^4 + 6\omega + 3 \geq 0 \;\forall \omega$

∴ $F(s)$ is PRF:

check PRF لازم أعمل check for Horwitz قبل ما أعمل

$F'(s) = 2s^3+3s^2+3s+3+s^2+1$

$= 3s^3+4s^2+3s+4$

$m'(s) = 4s^2+4$

$n'(s) = 3s^3+3s$

واقسم الكبير على الصغير

$4s^2+4 \;\big)\; 3s^3+3s$

$\boxed{\tfrac{3}{4}s} \qquad 3s^3+3s$

0

∴ $\frac{3}{4}s+1$

$4s^2+4 \;\big)\; 3s^2+4s^2+3s+4$

$3s^2 + 3s$

$4s^2+4$

$4s^2+1$

0

∴ $(4s^2+4)(\frac{3}{4}s+1) = 0$

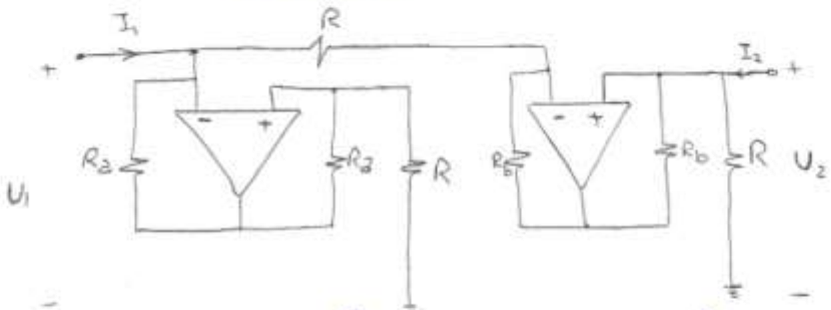
$s = \pm j \qquad s = -4/3$

LHS

∴ Herwit.

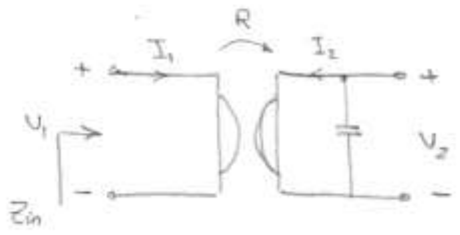
Network Realization

Deboo


I₁
R
I₂
+
+
V₁
R₃
R₃
R
R_b
R_b
R
V₂
-
-

$\equiv$ Gyrator (2opamp + 7R)

Grounded inductor

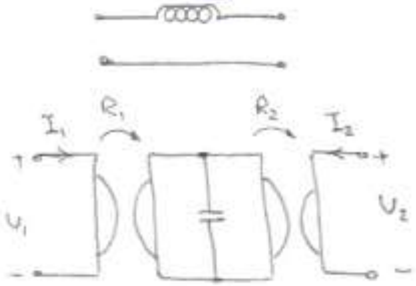

R
I₁
I₂
+
+
V₁
V₂
Zin
-
-

$L = R^2C$

10 element

(2opamp + 7R + 1C)

Floating inductor

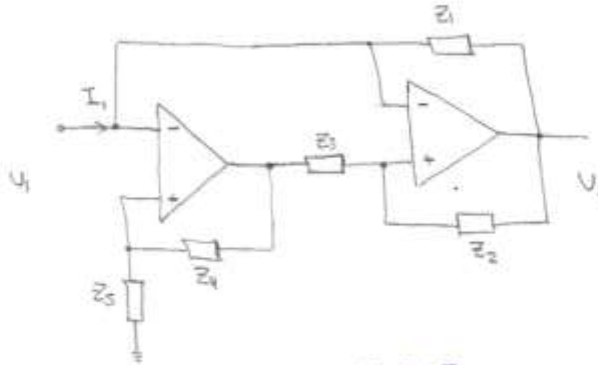

I₁
R₁
R₂
I₂
+
+
V₁
V₂
-
-

$L = R^2C$

19 element

(4opamp + 14R + 1C)

Riorden


Z₁
I₁
V₁
Z₃
V₂
Z₂
Z₄
Z₅

$$Z_{in} = \frac{V_1}{I_1} = \frac{Z_1 Z_3 Z_5}{Z_2 Z_4}$$

FDNR

(2 op-amp + 3R + 2C)

$Z_1 = Z_3 = Z_5 = R$

$Z_2 = Z_4 = 1/SC$

$\therefore Z_{in} = -\omega^2 C^2 R^3$

$Z_2 = Z_4 = Z_5 = R$

$Z_1 = Z_3 = 1/SC$

$\therefore Z_{in} = 1/\omega^2 C^2 R$

Grounded inductor

(2 opamp + 3R + 2C)

$Z_1 = Z_2 = Z_3 = Z_5 = R$

$Z_4 = 1/SC$

$\therefore Z_{in} = R^2 SC$

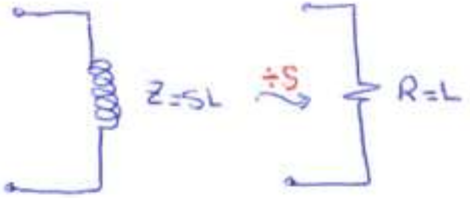
$\therefore L = R^2C$

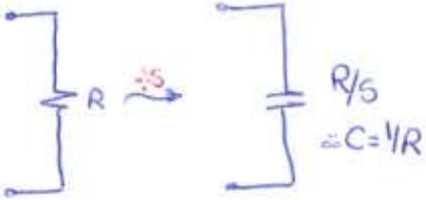
Floating induct.

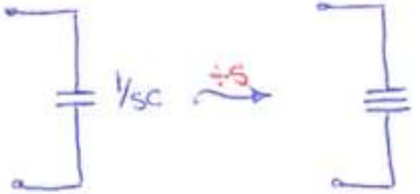
(2opamp + 7R + 2C)

Sheet 4

Bruton transformation







FDNR

$Z_c = 1/S^2C$

$Z_{in} = 1/\omega^2 C$

-5-

Realization of one port Network using LC

Foster I   Foster II   Cauer I   Cauer II

→ Foster(I) " It deals with $Z(S)$

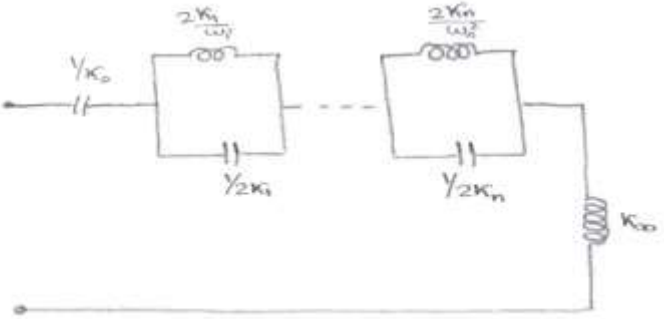
- $|\text{Degree of } N(S) - \text{Degree of } D(S)| \geq 1$
- It provide series Network
- $Z(S) = \frac{\text{odd}}{\text{even}}$ or $\frac{\text{even}}{\text{odd}}$

$$\therefore Z(S) = \frac{K_0}{S} + \sum_{n=1}^{n} \frac{2K_r S}{S^2+\omega_r^2} + K_\infty S$$

$$K_0 = \lim_{S \to 0} S\,Z(S)$$

$$K_\infty = \lim_{S \to \infty} \frac{Z(S)}{S}$$

$$2K_r = \lim_{S^2 \to -\omega_r^2} (S^2+\omega_r^2)\frac{Z(S)}{S}$$



→ Foster (II) It deals with $y(S)$

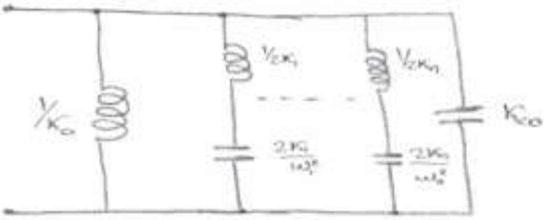
- $|\text{Degree of } N(S) \_ \text{Degree of } D(S)| \geq 1$
- It provide Series Network
- $y(S) = \frac{\text{even}}{\text{odd}}$ or $\frac{\text{odd}}{\text{even}}$

$$\therefore y(S) = \frac{K_0}{S} + \sum_{n=1}^{n} \frac{2K_n S}{S^2+\omega_r^2} + K_\infty S$$

$$K_0 = \lim_{S \to 0} S\,y(S)$$

$$K_\infty = \lim_{S \to \infty} \frac{y(S)}{S}$$

$$2K_r = \lim_{S \to -\omega_r^2} (S^2+\omega_r^2)\frac{y(S)}{S}$$



Cauer (I)

1. It deals with both $Z(s)$ & $Y(s)$

If Given $Z(s)$

1- $\lim_{s \to \infty} Z(s) = \infty$

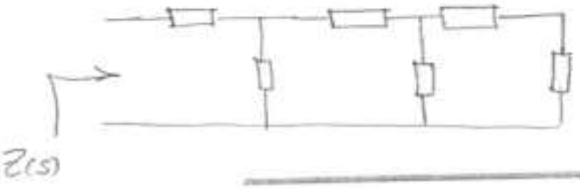
If given $Y(s)$

1- $\lim_{s \to \infty} Y(s) = \infty$

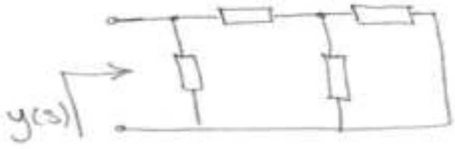
2. write both $N(s)$ and $D(s)$ in descending order ترتيب تنازلي

3. Apply continned fraction expansion قسمة بالطول

4. Draw the resulting network in Ladder form starting with Series element.



5. Draw the resulting network in ladder form start with parallel element.



Cauer (II)

1. It deals with both $Z(s)$ & $y(s)$

1- $Z(s)$

$\lim_{s \to 0} Z(s) = \infty$

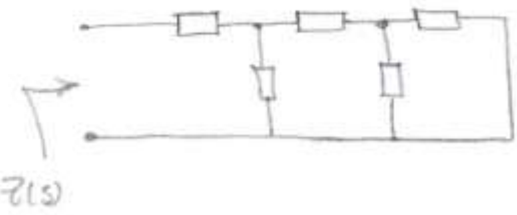
$y(s)$

$\lim_{s \to 0} y(s) = \infty$

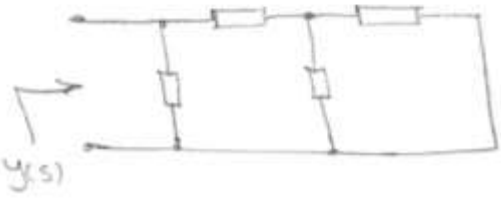
2. write both $N(s)$ and $D(s)$ in ascending order

3. Apply continned fraction expansion

4. Draw the resulting Network in ladder form start with series element



4. Draw the resulting network in ladder form start with parallel element.



-8-

Realization of one port Network using RC and RL

RC : $Z(s) = \frac{N(s)}{D(s)}$ or $y(s) = \frac{N(s)}{D(s)}$

$\frac{N(s)}{D(s)} = \frac{\text{odd} + \text{even}}{\text{odd} + \text{even}} <$ RC / RL

$Z(0) \geq Z(\infty)$
$y(0) \leq y(\infty)$ $\} \rightarrow$ RC

RL :

$Z(s) = \frac{N(s)}{D(s)}$ or $y(s) = \frac{N(s)}{D(s)}$

$\frac{N(s)}{D(s)} = \frac{\text{odd} + \text{even}}{\text{odd} + \text{even}}$

$Z(0) \leq Z(\infty)$
$y(0) \geq y(\infty)$ $\}$ RL

cauer I & II   زى الى قبل كدا

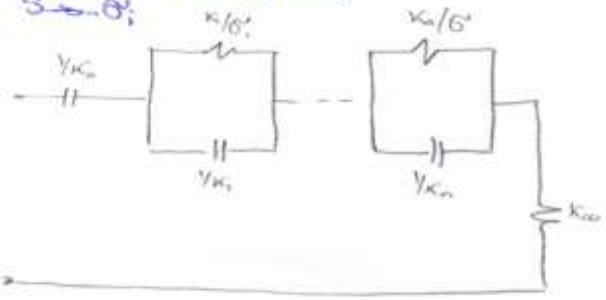
Foster (I)

$Z(s) = \frac{K_0}{s} + \sum_{i=1} \frac{K_i}{s+\sigma_i} + K_\infty$

$K_0 = \lim_{s \to 0} sZ(s)$

$K_\infty = \lim_{s \to \infty} Z(s)$

$K_i = \lim_{s \to -\sigma_i} (s+\sigma_i) Z(s)$



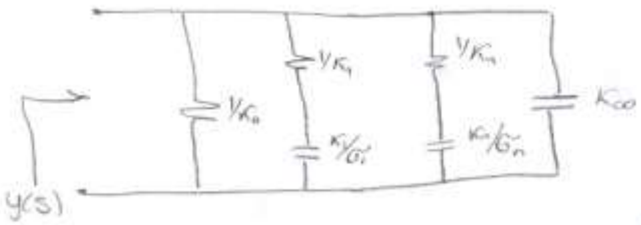
Foster (II)

$y(s) = \frac{K_0}{s} + \sum_{i=1} \frac{K_i}{s+\sigma_i} + K_\infty$

$K_0 = \lim_{s \to 0} sy(s)$

$K_\infty = \lim_{s \to \infty} y(s)$

$K_i = \lim_{s \to -\sigma_i} (s+\sigma_i) y(s)$



http://www.com-dep.tk/